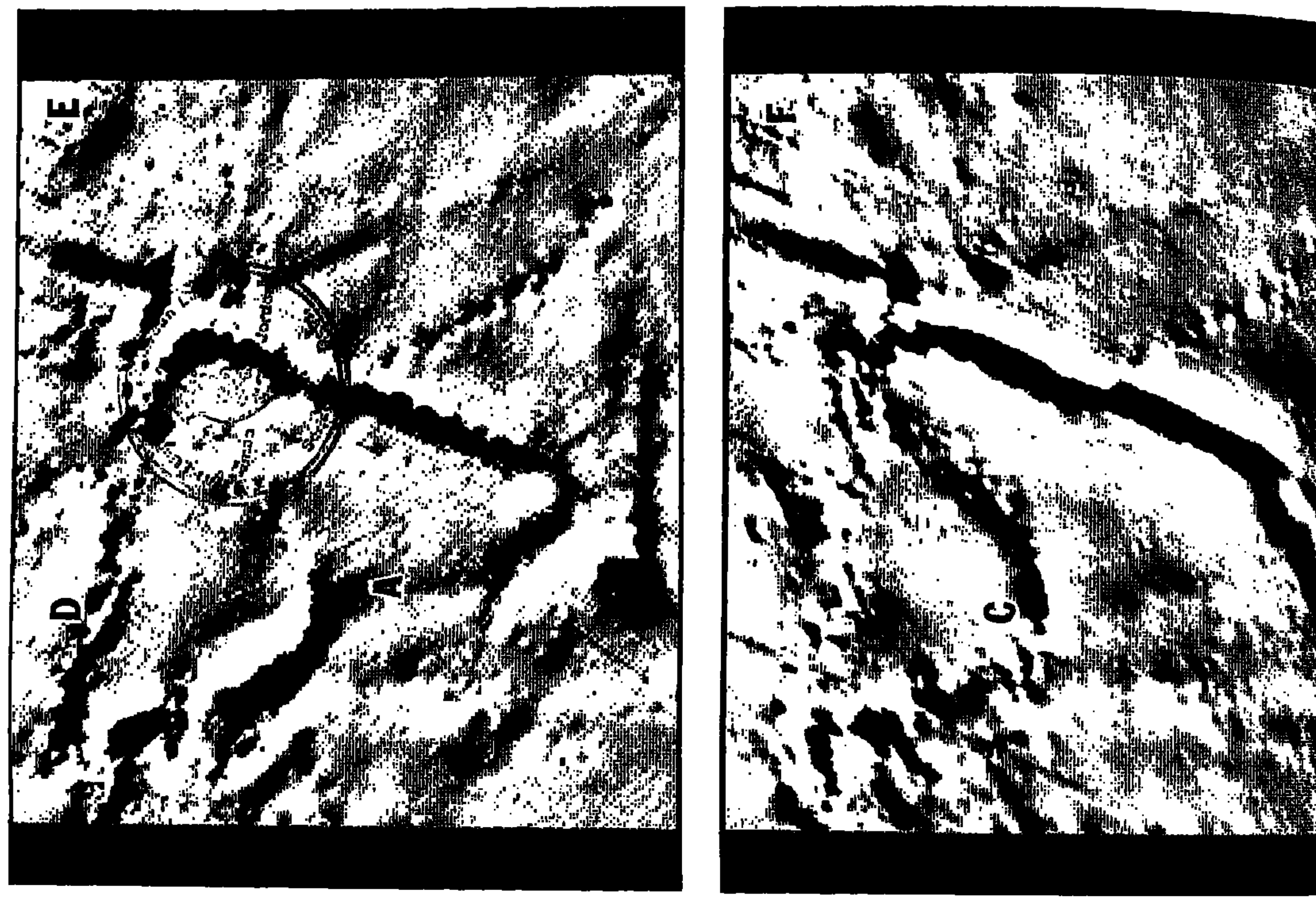
EOS Transactions, American Geophysical Union Vol. 64 No. 39 September 27, 1983



EOS, Transactions, American Geophysical Union Vol. 64, No. 39, Pages 569 - 576 September 27, 1983

Oceanography

4705 Boundary layer and exchange processes
WINTER MIXED LAYER ENTRAINMENT OF WEDDELL DEEP WATER
A. L. Gordon (Lamont-Doherty Geological Observatory of Columbia University, Palisades, New York 10964), C. T. A. Chen and W. G. Metcalf

Abstract. Observations from the SOMOV during the US-USSR Weddell Polynya Expedition show that the mixed layer below the sea ice just prior to the austral spring retreat in the 60°E-Greenwich meridian region, has an oxygen content of 7.4 ml/l. This is 86% of full oxygen saturation, representing an oxygen deficit, relative to full saturation, of 1.1 ml/l. The source of this deficit is believed to be a consequence of oxygen poor (4.5 ml/l) Weddell Deep Water (WDW) entrainment by the winter mixed layer. Assuming effective cut off of ocean-atmosphere oxygen exchange by the nearly complete snow and sea ice cover with no net impact of oxygen content due to biological factors, a mixing ratio of 1:3 for WDW to 'beginning of winter' surface water is required to explain the end of winter mixed layer oxygen content. Accompanying the WDW transfer into the mixed layer is heat transfer of approximately $7 \cdot 10^3$ cal/cm^2 ($2.9 \cdot 10^8$ Joules/m^2) during the five winter months of sea ice coverage as well as salt transfer, which requires 34 cm of fresh water to produce typical mixed layer salinity. During the seven ice free months when entrainment is expected to be minor, diffusive heat and salt flux continues. A mean annual heat flux of 12 Watts/m^2 is suggested, with an annual demand for fresh water of 46 cm/year. Consideration of the winter period salinity budget indicates net sea ice melting of 20 cm, which can be attributed to regional convergence of sea ice. The remaining fresh water is derived from excess precipitation and possibly iceberg melt. Oxygen undersaturation of the winter surface water suggests slightly less potential for abyssal water ventilation than might be expected from a fully saturated condition.

J. Geophys. Res., Green, Paper 3C1478

4713 Oceanography (Circulation)
TOPOGRAPHIC AND INERTIAL WAVES ON THE CONTINENTAL RISE OF THE MID-ATLANTIC BIGHT
Peter Hamilton (Science Applications, Inc., Raleigh, North Carolina)

Analysis of an array of four closely spaced moorings, 2800 m water depth, instrumented by near-bottom current meters, has been performed with a view to isolating coherent wave motions in the low frequency and inertial bands. [illegible]

[illegible]

4760 Oceanography (Sea Ice)
ANTARCTIC SEA ICE MICROWAVE SIGNATURES AND THEIR CORRELATION WITH IN SITU ICE OBSERVATIONS
J. C. Comiso (Goddard Laboratory for Atmospheric Sciences, NASA/Goddard Space Flight Center, Greenbelt, Maryland 20771) S. F. Ackley, and A. L. Gordon

[illegible]

4765 Oceanography (Meteorology)
LONG TERM CHANGES IN DYNAMIC HEIGHT

[illegible]

4799 General (Polynyas)
SATELLITE OBSERVED BEHAVIOR OF THE TERRA NOVA BAY POLYNYA

[illegible]

Particles and Fields—Interplanetary Space

5380 Solar wind plasma

[illegible]

News

In Congress

NASA Budget Set

Although the fiscal 1984 budget for the National Aeronautics and Space Administration (NASA) was signed into law in July, the agency only recently distributed the authorized funds to various programs. Unlike the U.S. Geological Survey and the National Oceanic and Atmospheric Administration budgets (*Eos*, September 13, 1983, p. 548), NASA had its budget signed into law well before the fiscal year began on October 1. Here is a summary of the authorizations for NASA and how the agency plans to distribute the funds.

Congress authorized a NASA budget of $7.3 billion, up from the agency's fiscal 1983 budget of $6.8 billion. President Ronald Reagan signed the budget into law (P.L. 98–52) on July 15. The lion's share—$5.9 billion—of the NASA budget goes to research and development (see Table 1). NASA officials, using the authorizing levels as a strict guide, distributed the funds to the various programs (see Table 2). NASA must ask congressional appropriations committees to approve the minor discrepancies between this distribution and the authorizing legislation. Among such discrepancies: The physics and astronomy subactivity was authorized for $562.1 million, but NASA officials set a program level of $567.6 million. NASA set the program level for planetary exploration, authorized for $220.4 million, at $217.4 million.

Eos will review the National Science Foundation budget in a coming issue.—*BTR*

TABLE 1. NASA Fiscal 1984 Budget: Research and Development Authorization, in Millions of Dollars

Activity	Reagan Proposal[1]	House Version[2]	Senate Version[3]	Authorization[4]
Space Transportation Systems				
Capability development	1927.4	2001.2	2009.4	2009.4
Operations	1570.6	1570.6	1545.6	1545.6
Subtotal	**3498.0**	**3571.8**	**3555.0**	**3555.0**
Space Science & Applications				
Physics & astronomy	514.6	566.6	562.1	562.1
Planetary exploration	205.4	220.4	220.4	220.4
Life sciences	59.0	59.0	59.0	59.0
Space applications[5]	289.0	306.0	313.0	313.0
Subtotal	**1068.0**	**1152.0**	**1154.5**	**1154.5**
Technology Utilization	**4.0**	**10.0**	**10.0**	**10.0**
Aeronautics & Space Technology				
Aeronautics	300.3	311.6	320.3	320.3
Space Technology	138.0	143.0	143.0	143.0
Subtotal	**438.3**	**454.6**	**463.3**	**463.3**
Tracking & Data Acquisition	**700.2**	**700.2**	**700.2**	**700.2**
Total, Research & Development	**5708.5**	**5888.6**	**5883.0**	**5883.0**

Source: NASA. Numbers may not total because of rounding
[1]See *Eos*, February 15, 1983, p. 65.
[2]From H.R. 2065, which passed the House of Representatives on April 26. See also *Eos*, May 17, 1983, p. 378.
[3]Passed by the Senate on June 28.
[4]Signed into public law (P.L. 98-52) on July 15.
[5]Includes solid earth observations, environmental observations, materials processing in space, communications, and information systems.

TABLE 2. NASA Science & Applications Fiscal 1984 Budget Distribution, in Millions of Dollars

Activity	Fiscal 1983	Reagan Proposal[1]	NASA FY 1984 Program Level[2]
Physics & Astronomy			
Space telescope development	137.5	120.6	195.6
Gamma Ray Observatory (GRO)	34.5	89.8	86.2
Shuttle/spacelab payload development & mission management	83.0	92.9	80.9
Explorer development	34.3	48.7	48.7
Mission operations & data analysis	74.8	79.5	68.1
Research & analysis	28.8	29.8	35.8
Suborbital program	48.1	53.3	52.3
Subtotal	**441.0**	**514.6**	**567.6**
Planetary Exploration			
Galileo development	91.6	79.5	79.5
Venus Radar Mapper (VRM)	0	29.0	29.0
International Solar Polar Mission	6.0	8.0	6.0
Mission operations & data analysis	38.5	43.4	43.4
Research & Analysis	50.3	45.5	59.5
Subtotal	**186.4**	**205.4**	**217.4**
Life Sciences	**55.7**	**59.0**	**58.0**
Solid Earth Observations			
Landsat 4	61.7	15.8	16.8
Shuttle/spacelab payloads	13.8	15.0	16.0
Geodynamics	26.2	28.0	20.5
AgRISTARS[3]	15.0	0	0
Research & analysis	13.7	14.6	14.6
Other[4]	1.8	1.0	7.5
Subtotal	**132.2**	**74.4**	**75.4**
Environmental Observations			
Shuttle/spacelab payload development	3.7	7.6	7.6
Operational satellite improvement program	6.0	0.6	0.6
Earth radiation budget experiment	24.0	15.5	15.5
Extended mission operations	22.8	27.4	27.4
Upper atmosphere research satellite experiments & mission definition	14.0	20.0	20.0
Research & analysis[5]	86.4	91.9	90.9
Subtotal	**156.9**	**163.0**	**162.0**
Materials Processing in Space	**22.0**	**21.6**	**23.6**
Communications	**32.4**	**21.1**	**21.1**
Information Systems	**7.5**	**8.9**	**8.9**
Total, Space Science & Applications	**1034.1**	**1068.0**	**1134.0**

Source: NASA. Numbers may not total because of rounding.
[1]See *Eos*, February 15, 1983, p. 65.
[2]These figures are program levels as distributed by NASA using the authorizations (see Table 1) as a guideline. NASA must seek approval from congressional appropriations committees for those program distributions that differ from the authorization levels.
[3]AgRISTARS concluded in fiscal 1983.
[4]Includes extended mission operations and laser network operations
[5]Includes research and analysis for upper atmosphere, atmospheric dynamics and radiation, ocean processes, and space physics programs.

Understanding Superfluids

Three researchers recently demonstrated that helium evaporates via a quantum mechanical process involving phonon (quantized sound wave) energy transfer; in doing so they may have taken the first step toward understanding the microscopic processes in classical liquids and solids (*Nature*, *304*, 325–326, 1983).

The result, obtained by M. J. Baird, F. R. Hope, and A. F. G. Wyatt, will have broad application even though helium itself is a quantum substance and in its superfluid state has properties of no other known material. In the fields of planetology and condensed-state mineral physics, investigators continue to try to understand the behavior of superfluid helium. The reasons for their effort extend from attempts to explain the fundamental dynamics of superdense stars to the practical matters of trying to predict the melting and boiling laws of planetary interiors.

On an even more practical level, laboratory geophysicists would like a better feeling for why helium seems to defy basic laws of physics by flowing more easily through narrow spaces than through wider ones; by fluid helium's allowing heat to flow at higher rates the smaller the thermal gradient; and by its refusing to accept the simple behavior of staying contained in any sort of experimental vessel.

Low-temperature (or high-density) helium may have a lot to offer as a condensed material in the study of how atoms can leave liquid and solid surfaces during evaporation. Helium in the superfluid state does not exhibit the usual signs of bubbling at the boiling point because its thermal conductivity is on the order of several thousand times that of normal materials. It is just such properties, however, that make liquid helium a good subject for studying how atomic bonding energy propagates through a liquid or solid and is transferred to a surface atom that is released to become an atom of vapor.

P. Gwynne recently described the behavior of superfluid helium as a sort of atomic counterpart to the electron behavior in superconductors (the National Science Foundation's *Mosaic*, May/June, 1983). In addition to the unusual properties described above, he noted that superfluid helium will flow toward a source of heat, that it prefers to creep unyieldingly up along the sides and over the lip of a bowl or flask, and that it shows independence of natural convention when it rotates. This last factor he describes as follows:

"Spin water in a flask, and it draws itself into a tighter whirlpool the faster it spins. If superfluid helium is spun inside a flask, the number of whirlpools inside the moving liquid multiplies as the speed of spinning increases. This multiple vortex effect has caught the attention of a number of theoretical physicists, who see it as an excellent example of the quantum mechanical nature of matter." One might stop to ask, What sort of fluid would form the multiple whirlpools whose vortices form at the symmetry points of a hexagonal lattice? Studies of the vorticity phenomena are currently one of the main areas of superfluid research in the laboratory.

At one atmosphere, liquid helium becomes a superfluid at 2.17 K. At the other extreme, in the interiors of pulsar stars, for example, helium becomes superfluid at incredibly high densities even though the temperature is extremely high—more than one million degrees. It could be that this superfluid behaviour affects the timing of radiation emission of pulsars. Baird et al. showed in laboratory experiments that the interaction between phonons and surface atoms in liquid helium is a "one-to-one" quantum process. These results and other work on superfluids could form a basis for understanding the evaporation and melting processes of condensed matter on the microscopic scale.—*PMB*

Federal R&D 1974–1984

The federal government distinguishes three types of activity under the title Research and Development (R&D), which was budgeted at $45.8 billion for 1984: basic research, applied research, and development. According to the National Science Foundation, the 1984 federal R&D obligation is 3 times the 1974 level. While the apparent 10-year growth of the R&D budget was about 10.2% per year in current dollars, real annual growth averaged only 2.5%. Moreover, averages themselves are misleading because most of the growth has taken place since 1981, mostly in defense programs.

The basic research portion of the 1984 R&D budget is $6.6 billion, one-third of which is allocated to biomedical research areas administered through the National Institutes of Health. However, the Department of Health and Human Services budget showed a real-dollar decline in 1984 of 3%. By contrast, the National Science Foundation budget, a portion of which also is granted for biological research, showed a less rapid rate of growth between 1974 and 1983, but had a real-dollar increase in the 1984 budget of 12%.

Applied research will be funded at an estimated $8.1 billion in 1984. Since 1978 this budget has shown a persistent downward trend amounting to 1.2% annually between 1978 and 1983, and 5% from 1983 to 1984. This trend has affected all federal funding agencies because of a shift of funds to basic research and to development programs.

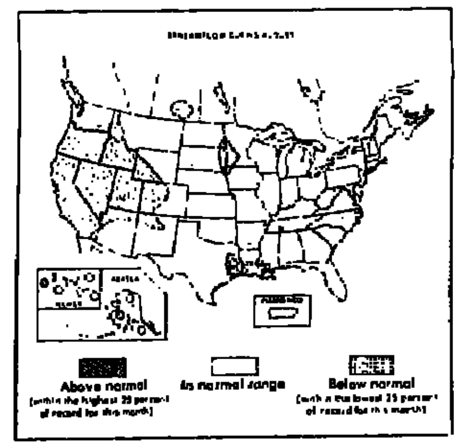
Development activities are budgeted at $31.1 billion in 1984. This amounts to a real dollar increase of 19%; 85% of these funds will go to the Department of Defense compared with 60% in 1979. According to the National Science Foundation (*Mosaic*, *14*, 42, 1983), while the defense share of development funds has been on the rise, "Reverse trends were shown by the other two leading support agencies. The Department of Energy accounted for 9% in the 1984 budget, compared with 20% in 1979. For the National Aeronautics and Space Administration the share was 3%, down from 17% in 1976. That was the last year in which the space shuttle was still completely in a development phase."—*PMB*

August Streamflow

Streamflow conditions in the far west remained in the above-normal range during August, with well above average flows reported from southern Washington south through California and as far east as central Colorado. In sharp contrast to the far west, extreme low-flow conditions persisted in parts of the Great Plains states, and the below-average flows that were reported only in scattered areas of the Southeast in July extended throughout the mid-Atlantic and southeast during August, according to the U.S. Geological Survey (USGS) (see map, courtesy of USGS).

USGS hydrologists said that the combined flow of the nation's three largest rivers—the Mississippi, St. Lawrence, and Columbia—reflected the contrast in the water picture, with the unusually high flows of the west balanced by the many low flows in the east. During August, the combined flow was 2237 billion liters per day (bld) (492 billion gallons a day), only 5 percent above the average and down 33 percent from July's combined flow. These three major rivers drain more than half of the coterminous United States and serve as a useful guide to the status of the nation's water resources.

Flows at the 172 key index gaging stations recorded by the USGS during August showed that 09 stations (57%) recorded streamflows



in the normal range, 41 stations (24%) recorded well above average flows and 32 stations (19%) recorded well below average flows.

Flows of the nation's five largest rivers for August: Mississippi River at Vicksburg, Miss., 968 bld, 1% above average, but 40% below the July flow; St. Lawrence River near Massena, N.Y., 814 bld, 5% above average, but down 2% from July; Columbia River at The Dalles, Ore., 455 bld, 8% above average, but down 50% from last month; Missouri River at Hermann, Mo., 186 bld, 13% above average, but down 42% from July; and the Ohio River at Louisville, Ky., 68 bld, 36% below the August long-term average and 54% below last month's flow.

Recent Ph.D.'s

Atmospheric Sciences

Boron in the Marine Atmosphere, Thomas R. Fogg, Center for Atmospheric Chemistry Studies, Graduate School of Oceanography, Univ. of Rhode Island, May 1983.

The Effects of Long-Range Transport of Air Pollutants on Arctic Cloud-Active Aerosol, Randolph D. Borys, Dept. of Atmospheric Science, Colorado State Univ., May 1983.

Hydrology

River Basin Water Quality Monitoring Network Design, Franklin S. Tirsch, Dept. of Civil Engineering, Univ. of Massachusetts–Amherst, May 1983.

A Markov-Weibull Model of Hydrologic Drought in the Farmington River Basin of Connecticut and Massachusetts, Richard James Dalphin, Environmental Engineering, Univ. of Connecticut, June 1983.

The Oceanography Report

Reading Thermometers

The Oceanography Report
The focal point for physical, chemical, geological, and biological oceanographers.

Editor: Arnold L. Gordon, Lamont-Doherty Geological Observatory, Palisades, NY 10964 (telephone 914-359-2900, ext. 325).

MIZEX West: Bering Sea Marginal Ice Zone Experiment

MIZEX West Study Group[1]

Introduction

The most thorough field study of the Bering Sea Marginal Ice Zone (MIZ) attempted to date was conducted February 5–27, 1983. This study, MIZEX West, was part of a larger program addressing processes which control interactions among the atmosphere, ice, and oceans in the northern hemisphere MIZ's [*Muench*, 1983*a*]. The other part of this overall program, MIZEX East, addresses processes in the Greenland Sea MIZ [*McPhee*, 1983*a*].

MIZEX West is an interdisciplinary, multi-institutional program that addresses a broad spectrum of physical problems related to the Bering Sea MIZ. Oceanographic studies attempt to measure and explain dynamically the frontal structure associated with the ice edge. Sea ice studies address the dynamic processes which control ice movement, floe interactions, and melting. Meteorological data contribute to knowledge of wind stress transfer through an ice cover and development of atmospheric boundary layers. Remote sensing information contributes to knowledge of the ice cover and enhances our ability to apply aircraft- or satellite-acquired data to the study of arctic regions. This article summarizes the goals, methods, and some preliminary results from MIZEX West.

The MIZEX West program took place along the central Bering Sea MIZ (Figure 1). This program consisted of an intensive field experiment in the vicinity of and north of the ice edge February 5–27, 1983, during the time of maximum ice extent and most rapid growth. The winter experiment employed the following research platforms:

(1) The NOAA Ship *Discoverer*. This vessel was equipped with a conductivity/temperature/depth (CTD) sensing system and with instrumentation for both surface meteorological and upper air observations. It was used as a base for deployment of personnel and remote instrumentation onto the ice, and housed equipment for recording data from these instruments and tracking them. With an ice-strengthened hull, the *Discoverer* was able to work in the relatively loose, broken ice in and near the ice edge.

(2) The U.S. Coast Guard Icebreaker *Westwind*. This ship was equipped with oceanographic and meteorological instrumentation similar to that on the *Discoverer* and was likewise used to deploy personnel and instrumentation onto the ice. In addition, *Westwind* had two helicopters which were used for gear and personnel deployment and recovery at locations remote from the ship. These helicopters were essential for such experiments as the wave attenuation experiment summarized below. The icebreaking capability of *Westwind* allowed it to operate in the relatively solid ice well north of the edge, where *Discoverer* could not penetrate.

(3) The NOAA WP-3D Research Aircraft. This aircraft was based in Anchorage, Alaska, and overflew the experiment five times. The aircraft was equipped with gust probes to measure atmospheric turbulence and a SLAR (side-looking air radar), laser profilometer, and cameras to observe ice properties. The WP-3D flew over the study region at altitudes between 50 and 1500 m.

(4) The NASA CV-990 Airborne Laboratory. The NASA aircraft, which was also based in Anchorage, was equipped with several passive microwave radiometers, an infrared radiometer, two cartographic cameras, and a version of the radar altimeter planned for the European Space Agency satellite ERS. The aircraft made five mosaic flights over the research area at an altitude of 10,000 m. Visual and photographic records of the general ice characteristics also made during the flights provided supporting data for interpreting the microwave measurements.

Information obtained from these four platforms was supplemented with current and other data from four moorings (Figure 1) which were deployed in October 1982 and recovered in May 1983 using the University of Alaska research vessel *Alpha Helix*.

The above research platforms and instrumentation constituted the MIZEX West core field program. Additional CTD data were obtained from the study area during the period from February 20 to March 18 using the U.S. Coast Guard icebreaker *Polar Sea*. Imagery was also obtained routinely from both the Nimbus and NOAA satellites. Finally, the National Weather Service office in Anchorage, Alaska provided real-time surface weather maps and ice distribution charts.

The Scientific Program

Oceanographic Studies

The oceanography portion of the program focused upon improving understanding of the oceanic frontal structure associated with the Bering Sea ice edge [*Muench*, 1983*b*]. To this end, four taut-wire current moorings were deployed at locations (Figure 1) which bracketed the winter ice edge. Depths of current observation (Figure 2) were selected so as to measure currents in the upper and lower layers and near the frontal transition, as illustrated on Figure 6. In addition to the current meters, bottom-mounted pressure gauges were deployed at moorings 1, 2, and 5 to measure fluctuations in the crest-shelf pressure field. The near-surface meters on moorings 2, 4, and 5 were vector-averaging acoustic current meters; the remaining current meters were Savonius rotor units.

To augment the current data, temperature (T) and salinity (S) transects were made across the ice edge from three different vessels from February 5 through March 18. These T and S data were sufficient to estimate mesoscale temperature and salinity features associated with the midwinter ice edge. The CTD data were supplemented with time-series of temperature obtained from each of the current meters and pressure gauges and with salinity data from the middepth current meters at moorings 2, 4, and 5. In addition to the winter data, CTD data were obtained from the study region in October 1982 and May 1983 during the deployment and recovery of the current moorings.

The current and CTD data obtained during MIZEX West provided excellent definition of the ice-edge-associated oceanic frontal structure. Figure 2 shows preliminary results from the current meters. The high, north-northwestward, near-surface current speeds associated with the ice edge front in February and March are apparent. These speeds were highest (nearly 0.15 m s^{-1}) in March at mooring 5, at a time and location where ice melting would be expected to contribute maximum freshwater input (hence baroclinic driving for the ice edge current) to the water column. Also apparent is the regional mean northwestward flow which persisted throughout the mooring period.

The CTD data substantiated the frontal structure described for the Bering Sea ice edge region by *Muench* [1983*b*] and shown schematically in Figure 6. These data were adequate, moreover, to define temporal fluctuations in the T and S fields and to greatly improve existing documentation of regional winter T and S distributions.

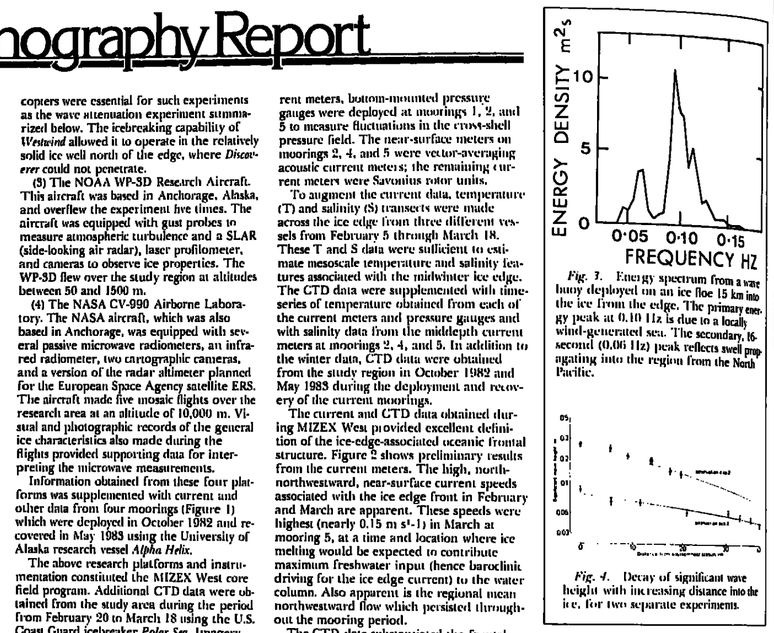


Fig. 1. Geographical location of the MIZEX West operations area. Solid line encompasses the area covered by the NOAA Ship *Discoverer*. Dotted line encloses the area covered by the Coast Guard Icebreaker *Westwind*. Numbered dots show locations of current moorings. Dashed line indicates approximate ice edge location during the experiment.

Fig. 2. Monthly vector-averaged currents obtained from the MIZEX West moorings. Mooring locations are shown in Figure 1 and depths of observations are given in meters at the left end of each time-stick.

Wave-Ice Interaction Studies

The energy loss suffered by ocean waves traveling through Bering Sea pack ice was studied during three experiments that took place from *Westwind*. The importance of these waves lies in their ability to fracture the large interior floes into smaller floes which are typical of the MIZ. In each experiment the wave-induced vertical acceleration (heave) of ice floes was measured along a line in the direction of the principal swell as observed from *Discoverer*. Whenever possible, the station separation was chosen to be the maximum possible within the constraints of helicopter range. The data were collected by vertical accelerometers allowed to record for 20 minutes at each successive location.

Preliminary power spectral analyses of the vertical acceleration data have revealed that ocean waves present during each experiment were at unusually long periods (Figure 3). The lowpass filtering effect of the ice cover could be clearly seen in the data, as spectral peaks became narrower with increasing distance from the ice edge. The decay in significant wave height with distance from the most southerly station in a given transect is shown in Figure 4. There is excellent agreement between the observed wave attenuation and a simple exponential decay law.

Fig. 3. Energy spectrum from a wave buoy deployed on an ice floe 15 km into the ice from the edge. The primary energy peak at 0.10 Hz is due to a locally wind-generated sea. The secondary, 16-second (0.06 Hz) peak reflects swell propagating into the region from the North Pacific.

Fig. 4. Decay of significant wave height with increasing distance into the ice, for two separate experiments.

Ice Dynamics Studies

Sea ice motion in the MIZ was measured with three different sets of buoys deployed from both *Westwind* and *Discoverer*. A set of four radar-tracked buoys deployed on the ice from *Westwind* had horizontal separations ranging from 0.5 to 5 km and was tracked at 0.5-hr intervals over an 11-day period using the LORAN-C and the radar range and bearing of each buoy. This radar-tracked array was nested inside a second triangular array of eight satellite-tracked ARGOS buoys with separations of 10 to 40 km (Figure 5). These buoys drifted westward approximately 350 km in 14 days, while the ice edge advanced 30 km. Two of the array sites were equipped with an anemometer, current meter, and air and water thermistors; these data were recovered through the GOES satellite. Comparison of the drift data with 10-m winds shows that the ice floes initially drifted at 4% of the wind speed, increasing to 7% of the wind speed within 80 km of the ice edge.

A similar series of ice drift and deformation experiments was done in the ice edge region from *Discoverer*. These experiments documented further the rapid drift and divergent ice field near the ice edge.

The radar transponder drift buoys each contained tri-axial accelerometers which measured vertical and horizontal accelerations of the ice floes in the 0.5 to 20 s range. These accelerations were transmitted for 20 minutes out of each hour to the ships for recording. The acceleration data show both propagation of ocean swell into the pack and high-frequency ice collisions.

In addition to the deformation studies, ice floes were instrumented along the edge to test the hypotheses of *Wadhams* [1983] and *Martin et al.* [1983] that locally wind-generated waves herd the loose ice along the edge into bands, then drive these bands in a slow wind direction to effectively increase ice convergence at the edge. The results confirmed the effectiveness of this mechanism. Two other classes of ice edge bands were also observed. In at least one instance a band was parallel to, and apparently caused by, the wind field associated with an atmospheric vortex, as suggested by *Muench and Charnell* [1977]. Additional bands were observed which had formed from a regular array of narrow leads which opened normal to the wind direction. A marked circulation of individual ice floes internal to each band was also noted. This circulation was capable of incorporating floes (or small boats) along the leeward edge of the band rapidly into the band interior.

Ice Edge Ablation

One of the major contributors to the ice edge salt and heat balance is the melting of ice floes as the wind advects them south across the front into warmer water. To study this melting, an ice floe measuring about 20 m by 40 m was instrumented with melt gauges over a 1.2-m thick, smooth portion of the floe. The floe was also instrumented with a current meter, an anemometer, and a radar transponder. It was then tracked over a 44-hour period as northeast winds blew the floe into warmer water at speeds of up to 0.5 m s^{-1}.

The floe was initially in sea water at -1.5°C. Over the next 24 hours the water temperature increased from -1.5° to 0°C and the observed bottom melt rate was 7 mm hr^{-1}. Over the next 20 hours the water temperature increased to +1.0°C, and the melt rate increased to 20 mm hr^{-1}. Over the entire 44-hour experiment, the ice thickness decreased by 0.8 m. At the same time, the floe was carried into near-open water and suffered severe erosion at the top and sides from waves washing over the floe. This increase in bottom, top, and side melting (occurring as the water temperature increased owing to floe advection and wave erosion at the sides and edges) supports the idea derived from previous cruises that the +1.0°C isotherm is the boundary between open water and ice. The data acquired will allow testing of theories by *Josberger* [1983] and *McPhee* [1983*b*] concerning ice melting.

Meteorological Observations

The meteorological observation program focused on boundary layer processes associated with passage of air from the ice cover over open water and upon vertical fluxes of heat, moisture, and momentum. Surface observations obtained from both vessels and ice camps deployed from the *Westwind* included air temperature, humidity, wind speed and direction, and pressure. Upper air observations taken from both vessels included temperature and humidity. Gust probe measurements taken during five flights of the NOAA WP-3D Research Aircraft allow estimation of vertical fluxes of heat, momentum, and moisture. Upward- and downward-looking radiation measurement devices were used to estimate radiative fluxes.

The data obtained appear adequate to construct an atmospheric heat budget for the MIZ region. The meteorological conditions which prevailed through the field program (northeast winds blowing off-ice) yielded strong boundary layer development along the ice edge. Hence the data are expected to be useful for testing a hypothesis proposed for MIZ boundary layer development by *Overland et al.* [1983]. Combined wind, ice, and water motion observations should also be adequate to test previous drag coefficient values reported by *Pease et al.* [1983] and *Macklin* [1983].

Remote Sensing Studies

A major goal of the remote sensing program is to study microwave radiometric properties of the Bering MIZ for the purpose of further improving sea ice concentration retrievals from space observations. Although passive microwave techniques have a proven ability to provide useful sea ice observations under all conditions of weather and seasons, there are still-unresolved problems which limit significantly the accuracy of calculated ice concentrations [*Cavalieri et al.*, 1983]. This is especially the case in the marginal ice zones, which are characterized by new ice production and growth and by rapid ice cover changes. The problem is to resolve ambiguities that are associated with the presence, within the field-of-view of the instrument, of open water and of new, young, and thin first-year ice types. Variations in ice type coverage are suspected to result in false concentration gradients within both the ice-edge zone and interior pack.

One approach in resolving this problem will be to examine the polarization and spectral characteristics of the ice cover at wavelengths ranging from millimeter to centimeter in order to obtain distinctive microwave signatures for each of the various species of first-year sea ice. Data from both airborne and spacecraft sensors will be used for this purpose. The aircraft's 0.33-cm wavelength imaging radiometer, for example, gives excellent definition of the ice edge, ice bands, and areas of open water within the pack. Variations of brightness temperature from consolidated pack ice presumably reflect variations of surface characteristics associated with different ice types. Other approaches to this problem will include combined active/passive studies employing selected passive microwave wavelengths and radar altimeter returns.

Preliminary results from a comparison of Nimbus 7 satellite microwave imagery with aircraft observations confirm that the satellite correctly locates the ice edge position and the regions of low ice concentration associated with ice shore polynyas (see cover figure). However, a significant fraction of the concentration gradients within the interior pack derived from satellite data results from spatial variation of ice type. In the cover figure, for instance, currently calculated ice concentrations of 85% or greater are associated with a first-year thin or medium ice cover; concentrations between 65% and 85% are associated with young ice; and concentrations below 55% are associated with new ice. Further analysis, however, has shown that the 0.81-cm polarization can distinguish among new, young, and first-year sea ice. This result holds promise for the discrimination of these first-year ice types. We hope that further analysis using other wavelengths will uncover distinctive spectral signatures needed to identify unambiguously each of the ice types. Analysis of surface radiometric measurements and ice core results, obtained from both ships, should help confirm these early observations.

Summary

Figure 6 summarizes the observations from MIZEX West. The buoy drift results suggest that the MIZ divides into two parts: region I, where ice motion at the 1–5 km scale is nearly solid body (i.e., is nearly that of a single mass) and where "leads" (irregular, ice-free areas) rapidly fill with ice; and region II, where the ice disperses in a near-random motion superimposed on the wind-driven displacement.

The region in which ice dispersion occurs is over the geostrophic current shear region associated with the ice edge front. Across this zone, the sea water temperature increases from the freezing point to approximately +1°C. The ice is broken up by ocean swell propagating into the pack and melts in the warmer water. At the same time, turbulent fluctuations associated with winds and currents deform and stretch the masses of ice into filaments or bands. Wind-waves generated on the open water accelerate those bands into the warmer water. There, ice melting over this two-layered system contributes to upper layer stability and helps maintain the alongfront geostrophic flow.

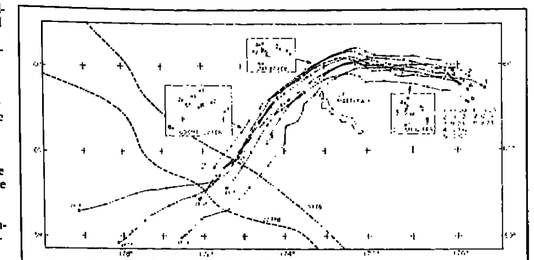


Fig. 5. Drift tracks for the eight ARGOS buoys deployed on the ice from *Westwind*. Dashed lines show approximate ice locations on February 10 and 22. Inserts show relative locations of the buoys. Numbers at the beginning and end of track give the day counting from February 1 (UT). RCVD indicates recovery of the buoy.

As the wind blows over the open water of region II, the surface conditions change from cold ice to warm water. The corresponding flux of heat into the atmosphere creates a rapidly developing, unstable boundary layer which leads to the formation of roll vortices aligned approximately parallel to the wind and additional turbulence at the ocean surface.

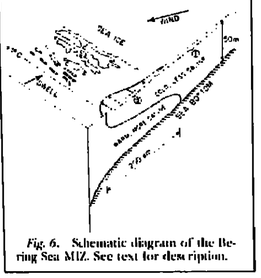


Fig. 6. Schematic diagram of the Bering Sea MIZ. See text for description.

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Cover. Sea ice concentration contours of the Bering Sea were obtained with the 37 GHz (0.81 cm) SMMR (scanning multichannel microwave radiometer) radiances from a single overpass of the Nimbus 7 satellite on February 19, 1983, during the Bering Sea Marginal Ice Zone Experiment (see "The Oceanography Report," this issue). Contours are drawn every 10% from 25% to 85%. The ice edge is defined by the sharp gradient of contours from 25% to about 65%. Within the ice pack, ice concentration variations reflect changes in ice type as well as open water amount. The insert shows the observed dependence of the polarization (V—H)/(V + H) at 37 GHz (0.81 cm) on ice type and open water for a number of selected observations. (NASA figure courtesy of D. Cavalieri.)

News & Announcements

Robert O. Reid Honored

Robert O. Reid, professor and head of the Department of Oceanography at Texas A&M University, was honored by about 80 of his former students with a two-day symposium on the practice of physical oceanography, held April 14 and 15 on the College Station campus. Some 30 papers were presented by Reid's present and former students, who came to Texas A&M from many parts of the country to honor their former professor. A festschrift of selected proceedings will be published by the Texas A&M University Press.

The symposium, planned by Feenan D. Jennings, director of the Texas A&M Office of University Research Services; A. D. Kirwan, Jr., University of South Florida; and William J. Merrell and Worth D. Nowlin, Jr., of the Texas A&M Department of Oceanography, was kept a secret from Reid until a reception the evening of April 13. Speaking on behalf of the symposium's organizers, Merrell noted that Reid has been on the graduate committee for 60 master's and Ph.D. students and committee chairman for 30 master's students and 55 doctoral students.

"We, his M.S. and Ph.D. students, believe that Professor Reid's greatest academic achievement has been in the guidance of graduate students. His scientific competence and interest combined with his kindness and patience make him uniquely qualified to guide graduate research," reads the dedication page of the symposium program. "We consider ourselves most fortunate in both the personal and professional sense to have had Professor Reid as a major professor—for we had the best. To honor his exceptional guidance of graduate students we dedicate this Symposium on the Practice of Physical Oceanography to Professor Robert O. Reid."

It concludes:

"Recognized internationally as a researcher, editor, and administrator in oceanography, Reid was named Distinguished Professor in 1978, and became head of the Department of Oceanography at Texas A&M in 1981. His academic career began with 2 years of study at the University of California, Los Angeles, after which he transferred to the University of Southern California to take mechanical engineering courses, which were not at that time (1941) offered at UCLA. Before completing the bachelor's degree at USC, he enlisted in the Army Air Corps Meteorology Cadet Program and was assigned to a unit at UCLA for training. During World War II Reid rose from second lieutenant to captain and served in Europe and the Pacific.

Reid completed the Bachelor of Engineering degree, magna cum laude, at USC in June 1946. Entering Scripps Institution of Oceanography in the fall of 1946, he met Marjorie Ferry, whom he married in February 1947. At Scripps, he studied under H. U. Sverdrup and Carl Eckart. He received the M.S. degree in oceanography in February 1948. Professor Reid cites Sverdrup and Eckart as the two men who have had the greatest impact on his professional outlook.

The Department of Oceanography was established at Texas A&M University in January 1949, and Dale F. Leipper was recruited from Scripps to head the new department. Leipper decided to assign his five academic positions to the basic disciplines of oceanography, including meteorological oceanography. Since he and Reid had wartime experience as both meteorologists and physical oceanographers, he decided further that the two of them could jointly fill the slots for both disciplines. Reid came to Texas A&M in January 1951 under this arrangement.

During a distinguished career of research, teaching, and advising, Professor Reid has received many honors, including full professorship and, in 1960, a Faculty Distinguished Achievement Award for Research; the Minnie Piper Foundation Award for Teaching, 1972; the Special Award of the American Meteorological Society, 1975; Medal of the University of Liège, Belgium, 1978; promotion to Distinguished Professor, 1978; election as a Fellow of the American Geophysical Union, 1980; and the Faculty Distinguished Achievement Award for Teaching, 1982. He was founding editor of the *Journal of Physical Oceanography*, serving from 1970 to 1980. In 1981 he accepted the position of head of the Texas A&M Department of Oceanography."

Christmas Island Birds Returning

Six months after their mass exodus, birds are beginning to return to Christmas Island. Roughly 17 million birds, almost the entire adult bird population, either perished or fled their mid-Pacific atoll home last autumn, leaving behind thousands of nestlings to starve (*Eos*, April 5, 1983, p. 131). It is believed that the strong El Niño altered the ecology of the surrounding waters and forced the birds to flee. Christmas Island is the world's largest coral atoll.

"Ocean and atmosphere scientists are unsure of future directions for the El Niño conditions and cannot now predict what will happen to the birds in the coming months," said Ralph W. Schreiber, curator of ornithology at the Natural History Museum of Los Angeles County in California. He is the ornithologist who discovered the disappearance. "The recovery of the bird populations depends on the food supply in the waters surrounding the island." The island's birds feed exclusively on small fish and squid.

As part of a survey on the biology of tropical seabirds as affected by the El Niño, Schreiber returned to the island for 10 days in June to survey the bird population. He reports that individuals representing most of the 18 species that fled have returned in small numbers. Three species are breeding at a rate approaching pre-exodus levels.

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POSITIONS AVAILABLE

Cornell University Department of Geological Sciences. Applications are invited for a tenure-track position at the assistant professor level to begin in Fall 1984. Specialties of interest are sedimentology, stratigraphy, and structural geology. Some experience beyond the Ph.D. is desirable. Send curriculum vitae and names of three references to

Donald L. Turcotte, Chairman
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The University of New Mexico/Research Associate. Applications are invited for a permanent position as a research associate in the Department of Geology at The University of New Mexico. The applicant should have experience in characterizing the structure, morphology and chemistry of solid materials with the analytical electron microscope (to be purchased this year) and will be responsible for the day-to-day operation of the instrument. The work will involve the characterization of metallic, ceramic and composite materials, including rock-forming minerals. The scanning transmission electron microscope will be part of an Electron Microbeam Analysis Facility which includes a fully-automated ARL EMX-SM electron microprobe; an automated, five spectrometer, 733 JEOL Superprobe and an Hitachi 450 scanning electron microscope. Each instrument has an EDS and is housed in newly constructed laboratories. Experience in x-ray diffraction crystallography and secondary x-ray fluorescence analysis would be useful.

The successful applicant is expected to maintain his/her own active research program and to interact with faculty throughout the University in cooperative materials science research.

A Ph.D. is required and the salary is in the range of $27,000 to $35,000/12 months commensurate with experience. Applicants should forward a detailed resume to R. C. Ewing, Department of Geology, University of New Mexico, Albuquerque, New Mexico 87131. Deadline for applications is December 15, 1983.

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Indiana University/Tenure Track Position in Igneous Petrology. The Department of Geology invites applications for a tenure track position in igneous petrology with strong emphasis on field plus experimental and/or theoretical considerations applicable to igneous rock systems. The duties of the appointment will consist of teaching on the undergraduate and graduate levels which will include petrology, petrography, and advanced courses in his or her own interest plus establishing a creative research program. The appointment will be at the assistant professor level and will take effect in August 1984. A doctoral degree is required. Applications, including a curriculum vitae and at least three letters of reference must be received by February 1, 1984. Please send inquiries and applications to Haydn H. Murray, Chairman, Department of Geology, Indiana University, Bloomington, Indiana 47405 (Phone: 812/335-5583). If applicants plan to attend the Geological Society of America meetings in Indianopolis, please arrange for an interview through the GSA employment service.

Indiana University is an equal opportunity/affirmative action employer.

Iowa State University of Science and Technology, Department of Earth Sciences. Applications are invited for a tenure track faculty position in Meteorology. Rank is at the assistant or associate professor level, dependent upon qualifications. The successful applicant will be expected to develop a strong research and graduate student program and will teach undergraduate and graduate courses for meteorology majors.

The position is for a person with proven expertise within the general area of dynamic meteorology. Teaching will involve an undergraduate course in synoptic meteorology, in addition to courses related to the field of expertise. Completion of the Ph.D. prior to appointment is strongly preferred. In addition, research ability shown by other publications and/or postdoctoral experience will be an advantage.

Iowa State offers degrees in meteorology through the Ph.D. The program includes about 60 undergraduate majors; the graduate/research program is strong and emphasizes theoretical, dynamic studies. Close relationships are established with the facilities and personnel of major national laboratories. New campus facilities for meteorology are currently under construction.

The appointment is expected to begin no later than September, 1984; an appointment during the current academic year may be possible. Application deadline is November 1, 1983; later applications will be accepted if the position is not filled. For application information please write to:

Dr. Bert E. Nordlie
Department of Earth Sciences
Iowa State University
253 Science I
Ames, Iowa 50011.

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South Dakota School of Mines and Technology. Applications are invited for two positions which may be available in the Department of Geolgoy and Geological Engineering. Both involve teaching at the graduate and undergraduate levels, thesis direction, and the development of research.

Geological Engineering: specialty in rock or soil mechanics, site evaluation, geohydrology, petroleum/reservoir engineering or engineering siesmologhy. Industrial experience desirable. A Ph.D. in an area of engineering is preferred.

Coal Geology: applicants should have a strong background in coal petrography, preferably with experience with U.S. coals. Experience as a palynologist/paleobotanist is desirable. The Ph.D. is required.

The department has an undergraduate enrollment of 170 majors and a graduate enrollment of 60. Field applications are emphasized. Interested persons should send a resume and three letters of recommendation to William Roggenthen, Dept. of Geology/Geological Engineering, South Dakota School of Mines & Technology, Rapid City, S.D. 57701. Deadline for application is December 15, 1983.

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National Center for Atmospheric Research/Visitor Applicants. At the High Altitude Observatory, Visitor Appointments are available for new and established Ph.D.'s for up to one year periods to carry out research in solar physics, solar-terrestrial physics, and related subjects. Applicants should provide a curriculum vitae including education, work experience, publications, the names of three scientists familiar with their work, and a statement of their research plans. Applications must be received by January 15, 1984, and they should be sent to: HAO Visitor Committee, High Altitude Observatory, National Center for Atmospheric Research, P.O. Box 3000, Boulder, Colorado 80307.

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The University of Missouri-Columbia/Faculty Positions. The University of Missouri-Columbia Department of Geology plans immediate expansion through the addition of three tenure-track faculty positions. Appointments are anticipated at the assistant professor level, although higher ranks may be possible, beginning in August of 1984. Candidates will be expected to have completed requirements for the Ph.D. degree by that time. Faculty members are required to provide quality instruction at both undergraduate and graduate level, and conduct research leading to schlorly publications. Successful candidates will be chosen from the following specialties:

Exploration Geophysics
Solid-Earth Geophysics
Hydrogeology
Analytical Structural Geology
Clastic Sedimentology

Applications should send resume, transcripts, and names and addresses of three references to:

Tom Freeman, Chairman
Department of Geology
University of Missouri
Columbia, MO 65211

Rensselaer Polytechnic Institute/A Tenure-Track Faculty Position and a Post-Doctoral Research Position. The Department of Geology of Rensselaer Polytechnic Institute is seeking applicants for two openings, a tenure-track faculty position and a post-doctoral research position.

The faculty position available in September 1984 requires a Ph.D. or equivalent degree. The area of specialization within the geosciences is open. Particularly important is the applicant's interest in research and teaching at both the undergraduate and graduate levels (M.S. and Ph.D.) with capability to do creative research in the quantitative sciences. Preference will be given to individuals with research experience beyond the Ph.D.; the level of the appointment is open.

The postdoctoral position is available beginning January 1984 to do research in the field of fission track analysis applied to studies of sedimentary basins. Applicants must be knowledgeable and experienced in fission track analysis.

Our present department is part of a modern, technologically-oriented university, and consists of seven members whose collective expertise encompasses structural geology, geophysics, geochemistry, petrology, glacial and surficial geology, and ecological modeling. The RPI environment provides ample opportunities for field and laboratory experimental research in geology, as well as for interdisciplinary studies in chemistry, physics, biology, mathematics, materials science, engineering and computer science.

A resume and the names of three persons who would be willing to provide letters of refereuce should be sent to: Donald S. Miller, Chairman, Department of Geology, Rensselaer Polytechnic Institute, Troy, NY 12181.

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Washington State University/Research Assistantships. Immediate openings for M.S. and Ph.D. Graduate Research Assistantships in the Laboratory for Atmospheric Research, College of Engineering, Washington State University. Current research includes measurements of hydroxyl radical concentrations; biogenic sulfur and hydrocarbon emission rates; global chemical concentrations in remote locations; investigations of atmospheric transport in complex surroundings; studies of pollutant-vegetation interactions. Write to Mr. Bob Koppe, Laboratory for Atmospheric Research, Washington State University, Pullman, WA 99164.

WSU is an Equal Opportunity and Affirmative Action Employer.

Ohio State University/Seismologist-Tectonophysicist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a geophysicist with research interests in seismology and/or tectonophysics. The successful applicant must be prepared to assist in teaching exploration geophysics courses, advanced topics in his/her speciality, conduct research, and supervise graduate students. Preference will be given to candidates with post-doctoral or industrial experience. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr.Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-1349 or 422-2721

Applications should include a resume, a statement of research interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

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Washington University, St. Louis. Washington University, St. Louis, announces tenure track positions for the fall of 1984. Preference is for candidates in Geophysics, Structural Geology, Metamorphic Petrology, or Petrology of Extraterrestrial Materials.

The successful candidate must have the following attributes: demonstrated creativity and promise of excellence in research and teaching; intent to develop a vigorous graduate research program; desire to teach courses in field of interest and related fields of geoscience at undergraduate and graduate levels.

Send resume, statement of future research interests, and names of at least three references to Larry A. Haskin, Chairman, Department of Earth and Planetary Sciences, Washington University, St. Louis, Missouri 63130. Applications received through January 1, 1984.

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North Carolina State University/Marine Chemist. The Department of Marine, Earth, and Atmospheric Sciences invites applications for a 9 month, tenure track position at the assistant or associate professor level. The candidate must have a Ph.D. and will be expected to interact with various research programs within the department such as: radiochemistry, stable isotope and trace metal geochemistry, sedimentology, ocean circulation, air-sea interaction, and biological oceanography. Responsibilities include conducting a viable research program as well as teaching and advising graduate students. Applicants should forward a resume and the names of at least three references to: Dr. David J. DeMaster, Chairman, Search Committee, P.O. Box 5068, North Carolina State University, Raleigh, NC 27650. Application material should be sent by November 30, 1983.

North Carolina State University is an equal opportunity/affirmative action employer.

Ohio State University/Structural Geologist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a structural geologist with a strong background in quantitative analysis of field data and research interests in regional tectonics or tectonophysics. The successful applicant will be expected to participate in the undergraduate program and give graduate courses in his/her field of expertise, conduct research, supervise graduate students, and interact with other departmental programs in regional geology and geophysics. Preference will be given to candidates with post-doctoral or industrial experience. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Ralph R.B. von Frese
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-5635 or 422-2721

Applications should include a resume, a statement of research interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

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Meteorologist/The City College of The City University of New York. The Department of Earth and Planetary Sciences invites applications for an anticipated opening in meteorology. The appointment will start September, 1984. Applicants should have completed the Ph.D. by the time of appointment and have a strong background in synoptic meteorology and computer applications. In addition, the individual should have an interest in atmospheric chemistry or pollution as applied to urban areas, or physical oceanography. The person hired will be required to teach courses in meteorology, and possibly physical oceanography as well as develop and maintain an active research program. Participation in the C.U.N.Y. Ph.D. Program in Earth and Environmental Sciences is anticipated. Rank and salary will be commensurate with experience. Send resume, transcripts and three letters of reference by November 30, 1983 to Professor Dennis Weiss, Chairman, Department of Earth and Planetary Sciences, the City College, 138 Street and Convent Avenue, New York, N.Y. 10031.

The City College of the City University of New York is an equal opportunity affirmative action employer.

Postdoctoral Position. Available for the experimental study of the entrainment, deposition, and transport of sediments in lakes and oceans. The research will be primarily in the laboratory but will also involve some field work. Competence in experimental fluid mechanics and interest in environmental problems is necessary. The position will remain open until filled. Applicants should send resume and names of three references to:

Professor Wilbert Lick
Department of Mechanical & Environmental Engineering
University of California
Santa Barbara, CA 93106

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University of Alaska/Exploration Geophysicist—Seismic Stratigrapher. Applications are invited for a tenure-track teaching/research position in the Geology/Geophysics Program of the College of Environmental Sciences. Prime responsibilities will be to teach graduate and some undergraduate courses in the use of state-of-the-art techniques in petroleum exploration geophysics. The successful applicant will also develop an innovative research program to complement our growing petroleum geology curriculum. Doctorate is required. Industrial experience in hydrocarbon exploration and, in particular, the use of seismic reflection data to interpret stratigraphy and facies is desirable. The nine-month faculty position is open starting in January 1984. Rank and salary commensurate with qualifications and experience. Resume and at least three references should be submitted to Dr. Juan G. Roederer, Director, Division of Geosciences, University of Alaska, Fairbanks, Alaska 99701. Applications will be accepted until December 15, 1983 or until position is filled.

Your application for employment with the University of Alaska may be subject to Public Disclosure if you are selected as a finalist.

The University of Alaska is an EO/AA employer and educational institution.

University of Florida. The Department of Geology invites applications for a tenure-track position beginning with the fall term, 1984. The position will be filled at the assistant or associate professor level. A Ph.D. is required and salary will be commensurate with qualifications. Although any research specialty will be considered, preference will be given to those with interest in these general areas: geochronology-isotope geology or low-temperature geochemistry-chemical sedimentology. Send curriculum vitae and 3 letters of reference by January 15, 1984 to: Dr. N.D. Opdyke; Department of Geology; 1112 GPA; University of Florida; Gainesville, Florida 32611.

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Department of Geosciences/University of Houston. The Department of Geosciences is interested in having applications for tenure track positions in the following areas: (1) Geophysics—seismology, exploration, data processing (2) Petrology—sandstones and metamorphic (3) Geochemistry—diagenesis

Salary and rank commensurate with experience. If interested, please send:

(1) A curriculum vitae

(2) A brief statement of teaching and research interests

(3) Three letters of recommendation to:

Dr. John C. Butler
Department of Geosciences
University of Houston
Houston, Texas 77004

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Professor of Marine Geophysics Tectonics/Stanford University. The Department of Geophysics, Stanford University, is seeking candidates for a tenure track position in the broad area of marine geophysics and tectonics. We seek a creative scientist with experience in gathering, interpreting, and synthesizing marine geophysical data and whose research interests cover depositional, igneous, and tectonic processes on oceanic plates and continental margins. Inquiries are invited from marine geophysicists with demonstrated scientific record in one of the above aspects of marine geophysics or tectonics, who have demonstrated an ability to develop new ideas and research directions, and to guide and teach graduate and undergraduate students. In considering this appointment we are interested in maximizing interactions with ongoing research groups in marine geology, plate tectonics, paleomagnetism, seismology and regional geology at Stanford. Our new faculty member will be expected to develop a strong research program involving both government and industrial participation.

Salary and rank will be commensurate with experience and background. Please submit a resume, a brief description of teaching and research interests and references to:

Dr. Amos Nur
Department of Geophysics
321 Mitchell Building
Stanford University
Stanford, CA 94305

Stanford University is an equal opportunity employer, and encourages the application of qualified women and minorities.

Earth Sciences

The Lamont-Doherty Geological Observatory of Columbia University invites scientists interested in any field of the earth sciences to apply for the following fellowships: Two postdoctoral fellowships, each awarded for a period of one year (extendable to two years in special instances) beginning in September, 1984 with a stipend of $25,000 per annum.

Completed applications are to be returned by January 15, 1984. Application forms may be obtained by writing to the **Director, Lamont-Doherty Geological Observatory, Palisades, New York 10964.** Award announcements will be made February 28, 1984, or shortly thereafter.

Columbia University is an Affirmative Action/Equal Opportunity Employer.

Laboratory Analyst and Manager/South Dakota School of Mines and Technology. Position as acting Assistant Director of Engineering and Mining Experiment Station at state-supported school of engineering and science located adjacent to the Black Hills. Experience required in standard chemical analysis, XRF, XRD, AA (ICP), ES, and energy dispersive wavelength techniques. Analytic work dominately in ores, minerals, fuels and water but includes engineering materials. Opportunity for individual research, work with graduate students, and instruction in short courses. M.S. degree minimum. Closing date, October 31, 1983.

An Equal Opportunity Employer.

Resume and three references to Jack A. Redden, Director, Experiment Station, South Dakota School of Mines and Technology, Rapid City, SD 57701–3995.

Princeton University. A limited number of one year visiting appointments, with the possibility of renewal, are available on a competitive basis for new and established Ph.D.'s to carry out research in dynamics and predictability of the atmosphere and oceans, climatology, atmospheric and oceanic chemistry, basic geophysical fluid dynamics, and solid earth geophysics. Successful applicants will have access to the facilities of the Geophysical Fluid Dynamics Laboratory/NOAA. Information and application forms can be obtained from: Chairman, Visiting Scientist Selection Committee, Geophysical Fluid Dynamics Program, Princeton University, Post Office Box 308, Princeton, New Jersey 08542.

Princeton University is an Equal Opportunity Employer—M/F.

University of Cambridge,Bullard Labs./Seismologist. Postdoctoral research position available in the Marine Geophysics Group. We have an active program involving two-ship multichannel seismic experiments on the U.K. continental margin, construction of digital OBS, seismic refraction experiments on the continental shelf, the deep oceans, passive and active margins and aseismic ridges, and the development and application of new interpretation methods, with opportunities to initiate new projects. Initially funded for 2 1/4 years.

Send resume and names of two referees or request for further details to Dr. R.S. White, Bullard Laboratories, Madingley Road, Cambridge, U.K.

An equal opportunity employer.

Louisiana State University/Tenure-Track Faculty Positions in Geology. The Department of Geology is expanding from 15 to 36 faculty with four positions open Fall 1984 and one position (Field Camp Director) open January 1984. Candidates must have the Ph.D. and have active research in progress that might be applied to studies of basins. Specialties of primary interest are field geology, theoretical seismology, hydrogeology, and organic geochemistry; however, other disciplines will also be considered with quality of research being the primary factor in applicant selection. All faculty in the Department are required to conduct research leading to publications and to provide quality instruction. The Department will expand into a new building January 1986.

For consideration send resume, three letters of reference and a description of research to Lyle McGinnis, Faculty Search, Department of Geology, Louisiana State University, Baton Rouge, LA 70803–4101. Search Will remain open until positions are filled.

LOUISIANA STATE UNIVERSITY IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER.

Ohio State University/Paleobiologist. The Department of Geology and Mineralogy, The Ohio State University, invites applications for a tenure-track position for a paleobiologists with a strong quantitative background; and the capacity to develop or expand a research program in biogeography, evolutionary paleobiology, functional morphology, or paleoecology that will augment existing programs in biostratigraphy, micropaleontology and sedimentary petrology.

Ph.D. or equivalent is required by the time of appointment. The successful applicant will be expected to teach graduate and undergraduate courses appropriate to their expertise, conduct research and supervise graduate students. Rank and salary commensurate with experience and research record. Please send applications or nominations as soon as possible to:

Dr. Walter C. Sweet
Chairman, Search Committee
Department of Geology and Mineralogy
The Ohio State University
Columbus, OH 43210
Phone: (614) 422-2326 or 422-8740

Applications should include a resume, a statement of research record and interests and the names of at least three persons whom we may contact for recommendations. The closing date for applications is December 23, 1983; appointments will be effective no later than October 1, 1984. Additional information can be obtained by writing or calling the search committee chairman.

The Ohio State University is an equal opportunity/affirmative action employer.

Louisiana State University/Chas. T. McCord, Jr. Endowed Professorship in Hydrocarbon Exploration: The Geology Department is seeking an internationally recognized leader in some research specialty critical to the search for oil and gas to fill the Chas. T. McCord, Jr. Endowed Professorship. Applicants are expected to maintain scholarly research in their area of specialty. Rank at Full Professor level with salary competitive with endowed professorships at other major research universities. For consideration send resume, three letters of reference, and a description of future research programs to Lyle McGinnis, Faculty Search, Department of Geology, Louisiana State University, Baton Rouge, LA 70803–4101. Search will remain open until position is filled.

LOUISIANA STATE UNIVERSITY IS AN AFFIRMATIVE ACTION/EQUAL OPPORTUNITY EMPLOYER.

Reflection Seismologists or Geologists. Bored by oil? BIRPS—academic seismic profiling at sea to 15 seconds—seeks postdocs for geological interpretation and innovative processing. Splendid environment. University salary. Send cv to Dr. Mathews, Earth Sciences, Bullard Labs, Cambridge University, England.

The State University of New York at Binghamton/Petrologist. The State University of New York invites applications for a tenure-track faculty position in igneous or metamorphic petrology beginning August, 1984. Appointment will be at the level of assistant professor. Candidates must have a Ph.D. degree by this date, and also the potential to develop a productive research program, as well as teach at the undergraduate and graduate levels.

Applicants should send a resume and names of at least three persons who can be contacted for references to:

Thomas W. Donnelly
Department of Geological Sciences
State University of New York
Binghamton, New York 13901

The State University of New York at Binghamton is an affirmative action/equal opportunity employer. The closing date for this position is December 15.

Geochemistry/University of Illinois at Urbana-Champaign. The Department of Geology invites applicants for a tenure-track faculty position in goechemistry. We are seeking candidates who have clearly demonstrated the potential to be outstanding researchers in the general area of low-temperature geochemistry and whose future research efforts will complement our existing programs in the petrology and diagenesis of sediments, stable isotope studies, and fluid-rock interactions. In addition to the development of a strong research program, the successful candidate is expected to participate in all aspects of teaching and advising at the graduate and undergraduate levels.

The Department of Geology houses a variety of facilities for geochemical research including an atomic absorption spectrophotometer, x-ray diffraction and fluorescence units, an isotope-ratio mass spectrometer, and two electron microprobes. Numerous other analytical facilities are available on campus.

This position is available immediately. We expect to make the appointment at the Assistant Professor level. Salary will be commensurate with experience and qualifications. For equal consideration, please submit a letter of application which includes a statement of current and future research interests as well as curriculum vitae, bibliography, and the names of 3 references willing to comment on your qualifications and promise to Thomas F. Anderson, Department of Geology, 245 Natural History Building, 1301 W. Green St., Urbana, IL 61801, (217)333-0355 by November 30, 1983. The University of Illinois is an equal opportunity/affirmative action employer.

Chairman-Department of Geological Sciences/Wright State University. The Department of Geological Sciences invites applications for the position of chairman to be appointed September 1984. We seek a dynamic individual with administrative talent and an appreciation for research and practice-related educational activities. Rank is at the full professor level and no restrictions have been placed on areas of specialization. The department is active with 12 faculty and an emphasis on professional practice, yet maintaining a firm commitment to basic reasearch.

Send a letter of application, curriculum vitae and names of three references to:

Chairman, Search Committee
Department of Geological Sciences
Wright State University
Dayton, OH 45435

Wright State University is an affirmative action/equal opportunity employer. Closing date for the position is October 31, 1983.

Stanford University/Civil Engineering. The Department of Civil Engineering is seeking candidates for a tenure-track faculty position at the level of Assistant Professor in the area of fluid mechanics starting September 1984. Candidates must have a Ph.D. and some professonal experience is desirable. Duties include teaching of undergraduate and graduate courses in fluid mechanics, and development of and participation in independant and team research in fluid mechanics, particularly as it interfaces with problems in environmental engineering and science. Candidates should have training and/or experience in experimental, theoretical, analytical, and numerical fluid mechanics. Particular strength in one of these areas is required.

Standford University has a strong insitutional commitment to diversity. In that spirit, we are particularly interested in receiving applications from women and ethnic minorities. Those interested in filing an application for the position should send a resume, college transcripts, a list of references, and representative publications (if available) to Professor Joseph B. Franzini, Department of Civil Engineering, Stanford University, Stanford, California 94305 by November 20th.

Stanford University is an equal opportunity employer through affirmative action.

STUDENT OPPORTUNITIES

GRADUATE STUDENT NASA TRAINEESHIPS

The Florida State University is accepting applications from prospective graduate students for participation in its NASA sponsored Traineeship Program in Oceanographic Remote Sensing Techniques and Physics of Air-Sea Interaction. The stipend for the calendar year is $10,600. Students may be enrolled for a degree in either oceanography or meteorology. For further information or application, please write:

Dr. James J. O'Brien
NASA Traineeship Program
Meteorology Annex
The Florida State University
Tallahassee, Florida 32306
(904) 644-4581

PAGEOPH

pure and applied geophysics

CALL FOR PAPERS

The journal Pure and Applied Geophysics (PAGEOPH) is undergoing major changes. As of January 1983 its newly established editorial board will operate on a three-year basis, and **PAGEOPH** will be published by the US-based Birkhäuser Boston, Inc. Keiiti Aki is the new Editor-in-Chief, assisted in atmospheric and oceanic science by Richard Lindzen. Renata Dmowska serves as Executive Editor. At present the editorial board consists of:

Enzo Boschi	Taroh Matsuno
Stuart Crampin	Takeshi Mikumo
Robert E. Dickinson	W.R. Peltier
S.J. Gibowicz	R. Alan Plumb
Eystein Husebye	Hans R. Pruppacher
Kurt Lambeck	Shri K. Singh
Douglas Lilly	Yi-Ben Tsai
Benoit Mandelbrot	Ren Wang
Takuo Maruyama	Max Wyss

The new editorial board plans to preserve the international character of the journal, simultaneously ensuring the highest standards through a vigorous effort to publish papers of interest and quality. The **PAGEOPH** tradition of special issues will be further developed. These special issues serve as both state-of-the-art surveys and as introductions to active areas of research. They will be published in regular journal format, and also in inexpensive softcover editions. All page charges for contributions in these special issues will be dropped. There are no page charges for the first 12 pages of any contribution accepted for regular publication in **PAGEOPH**.

The new editorial board has been chosen to be rather equally divided between atmospheric and solid earth scientists. Management and editorial policies will reflect this dual specialization, with the eventual possibility of separate issues. Subscribers can be assured of thought-provoking, current research in both fields of geophysical science.

The call for papers is being announced. Manuscripts in solid earth science should be submitted to:

Dr. Renata Dmowska, Executive Editor
Division of Applied Sciences
Harvard University
Pierce Hall
29 Oxford Street
Cambridge, MA 02138 USA

Manuscripts in atmospheric and oceanic sciences should be submitted directly to an editor of your choice. Acceptance or rejection by the editorial board is final. All manuscripts should be submitted in triplicate, typewritten with double line spacing and wide margins. Detailed guidelines for contributors can be found in each issue of **PAGEOPH**.

Inquiries concerning subscriptions and/or general information should be directed to the publisher:

BIRKHÄUSER BOSTON, INC.
P.O. Box 2007
Cambridge, MA 02139 USA
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PAGEOPH
pure and applied geophysics

AGU

Resolutions of the 18th General Assembly of IUGG

Reproduced below are the 19 resolutions adopted at the 18th General Assembly of the International Union of Geodesy and Geophysics (IUGG), held in Hamburg August 15–27.

The resolutions passed by each quadrennial general assembly of IUGG are an important barometer of current opinion in the geophysics community, and as such they can be a powerful tool in the development of the scientific programs to which they are addressed. The resolutions will help advance programs, however, only if they are used. Carried back home by the national committees which make up the IUGG, the resolutions spread information worldwide on programs that promise to most effectively advance geophysical knowledge. The IUGG intends that member groups will present the resolutions before deliberative bodies and otherwise use them to make decision makers aware of international scientific thought.

The following resolutions were adopted:

The XVIII General Assembly of IUGG:

1. Considering the scientific, technical, and economic importance of the **African Doppler Survey (ADOS)**;

Noting the significance of this program for improving the knowledge of the figure of the Earth and for coordinating the various geodetic networks in Africa;

Noting that two training seminars on Doppler techniques are to be organized in collaboration with the IAG, as well as the Third International Symposium on Geodesy in Africa in 1985;

Requests the international and national cooperative organizations to support these activities.

2. Considering the extraordinary international importance of the U.S. Navy Navigation Satellite System, both to the science of geodesy and to civil surveying in this field;

Noting that (1) this system is due to be discontinued; and (2) other precise satellite-based radio positioning systems such as **U.S. Global Positioning System (GPS)** and the **USSR Global Navigational Satellite System (GLONASS)** are being developed or conceived;

Strongly urges the appropriate authorities to make available to the international scientific and civil community the information necessary to obtain maximum position accuracy from the new system.

3. Noting that a goal of **Project MERIT** (measurement of Earth's rotation and intercomparison of techniques) is to complete a comparative evaluation of the Earth rotation results obtained by different techniques during a dedicated campaign;

Considering that detailed standards are being prepared to accomplish this goal;

Recommends that all MERIT results be referred to these standards; and

Urges that all participants in the Project adhere to the constants, models, and reference frames and to the protocols for their use as will be defined in the final MERIT Standard Document.

4. Noting that the **transfer of angular momentum between the oceans, atmosphere, and solid Earth** is rapidly emerging as a problem of great scientific importance, and in view of the significance of this coupling mechanism to fundamental studies in geodesy and solid-earth geophysics;

Recognizing that understanding the Earth's polar motion and rotation depends on an understanding of the effect of the atmosphere and oceans on the solid Earth;

Recommends that cooperative research efforts be encouraged in all countries in order to acquire relevant data and to bring together scientists from all disciplines in multidisciplinary studies of the angular momentum transfer between the solid Earth, the oceans, and the atmosphere.

5. Noting the recent demonstration that the **angular momentum transfer between the atmosphere and the solid Earth** evidently makes a major contribution to short-term variations in the length of the day and polar motion;

Considering that the Main Campaign of Project MERIT, during the period September 1, 1983, to October 31, 1984, will produce the highest resolution and most accurate measurements of Earth-rotation ever achieved;

Requests that the W.M.O. make every effort to collect the most complete possible set of global meteorological wind and pressure data and reduce these data in a consistent manner to obtain the highest quality atmospheric angular momentum and polar motion excitation function throughout this period, and especially during April through June 1984, concurrent with the period of high intensity MERIT observations.

6. Recognizing that the **middle atmosphere** is of crucial importance to the biosphere through the protection by ozone of the Earth's surface from harmful UV radiation, and because of its possible effects on tropospheric climate; and

Recognizing that understanding of middle atmospheric chemistry, radiation transfer, and dynamics is required for reliable prediction of the effects of human activity on the middle atmosphere;

Recommends that the agencies involved in space research develop and launch satellites to obtain the observations of radiation and chemical and dynamical processes required for uninterrupted growth in our understanding of these processes.

7. Recognizing (1) that the World Climate Research Program requires atmospheric and oceanic observations over oceans, and that termination of Ocean Station PAPA in the North Pacific in 1981 constitutes a serious loss to the climatic record, to atmospheric and oceanic research activities, and to operational weather forecasting; (2) that as a result of increasing cost of operation, special weather ships cannot be relied on to provide continuous fixed point observations, and that several North Pacific nations are cooperating under Canadian leadership in new ship-of-opportunity programs to provide oceanographic, surface meteorological, and upper air observations; and (3) the increasing capacity of satellites for oceanographic and meteorological observations over the world's oceans;

Commends the efforts of Canada and other cooperating countries in undertaking to develop a satisfactory **ship-of-opportunity observing system for the North Pacific**; and

Recommends that nations operating satellites over ocean areas be urged to take all steps to ensure the continuity and the quality of meteorological and oceanographic data.

8. Noting that more than ninety-five percent of the fresh water on the surface of the Earth is in the great sheets of Antarctica and Greenland, which may be subject to significant changes in volume on time scales of decades or centuries;

Aware that such changes *could*, through their effect on sea level, have an impact on mankind greater than all short-term climate-induced changes in lower latitudes;

Recognizing that there are at present no accurate data on changes in the total ice volume, but that now for the first time it is technically feasible by satellite altimetry to determine surface elevation changes as small as 0.5 m., which would allow detection of changes in volume of the Antarctic ice sheet of as little as 1 part in 5000;

Drawing attention to the fact that such changes would provide information about the effects of climate variations long before an unambiguous sea level signal was recognizable;

Wishes to point out the urgent need for and great value of including **precision altimetry on a truly polar-orbiting (87–97 degree inclination) satellite**; and

Urges that all altimeter-equipped satellites in high-latitude orbits should record the surface elevation of the Antarctic and Greenland ice sheets, and that these data should be made available to the scientific community.

9. Noting that the dynamics of the **equatorial middle atmosphere** are poorly understood, and, in particular, that there have been inadequate observations of such phenomena as equatorial waves, tides, gravity waves, and turbulence, and of their contribution to the momentum and heat budgets of this region, and taking into account the development of new ground based techniques such as MST/ST radars and lidars, and the refinement of partial reflection and meteor wind radars;

Recommends that one or more observatories which combine as many of these systems as possible be established at the earliest opportunity near the equator and preferably in the Eastern or Western Pacific, where extensive chains of stations already exist at high and mid-latitudes.

10. Noting the resolution of ICSU (Resolution 23 of Cambridge General Assembly) recognizing both the need for public understanding of the possible **consequences of the nuclear arms race** and the competence that could be mobilized by ICSU to make an assessment of the biological, medical, and physical effects of the use of nuclear weapons;

Noting further the establishment by the Scientific Committee on Problems of the Environment (SCOPE) of a project on the effects of nuclear war on the atmosphere and the subsequent establishment by the General Committee of ICSU of a broadly based Steering Committee to guide the SCOPE project and to coordinate further proposals for action by members of the ICSU family;

Recognizing the desirability of avoiding any undue dispersion of effort by scientists in relation to the objective assessment of the effects of nuclear war;

Urges all Associations to forward any proposals for additional action to the ICSU Steering Committee.

11. Recognizing that the need for cartographic representation of the **structure of the Earth's crust and upper mantle** has become urgent;

Invites all interested Associations to participate actively in the projects of the Working Group on the comprehensive mapping of the Earth's crust and upper mantle established jointly by IASPEI and the Commission on the Geological Map of the World of IUGS.

12. Noting the resolution of the International Union of Geological Sciences concerning the Unesco Subprogramme X.1.4.: **Interdisciplinary Research on the Earth's Crust**;

Endorses the general objectives of the Inter-Union Commission on the Lithosphere, and in particular, the special goal of strengthening the Earth sciences and their effective application in developing countries;

Supports the Resolution of the International Union of Geological Sciences; and

Urges the General Conference of Unesco to authorize the Director General to include an adequate budget allocation for scientific meetings and symposia of the Inter-Union Commission on the Lithosphere and thus help Unesco to meet the targets of its Major Programme X: The Human Environment and Terrestrial and Marine Resources.

13. Noting the number of recent incidents involving high-level **aircraft entering volcanic-ash plumes**, the difficulties of ground observers on or near volcanos providing warning to pilots in the air, and the potentially disastrous hazard of engine failure caused by ash intakes;

Recommends that much closer links be established between national volcano-monitoring agencies and regional air-traffic control and meteorological offices, and between international aviation organizations (such as the International Air Transport Association and the International Civil Aviation Organization) and the International Association of Volcanology and Chemistry of the Earth's interior.

14. Recalling Resolution 14 of the 17th General Assembly (Canberra), recommending the establishment of a **Volcanological Institute for the Western Pacific**;

Supports the Draft Project Document for improved training and research in volcanology in the Western Pacific that has been prepared by UNESCO's Regional Office for Science and Technology for Southeast Asia (ROSTSEA); and

Urges the UN to provide appropriate funds for the immediate implementation of this ROSTSEA project.

15. Noting the immense value to the scientific community of past international programs of coordinated data acquisition, analysis, and interpretation such as the International Geophysical Year, the International Year of the Quiet Sun, and the International Magnetospheric Survey;

Recognizing the importance, complexity, and dynamic nature of the **solar-terrestrial interaction**, and the need for international programs designated to acquire and analyze global data for quantitative investigations of the physical and chemical processes that are involved;

Urges member countries to support and to participate in ICSU programs on solar-terrestrial interaction, especially in the final analysis phase of the IMS and the continuation of the MAP and in similar programs now being planned for the coming decade.

16. Recognizing the fundamental role which radiative energy exchange processes play in the physics of the climate system;

Considering the requirements for accurate data sets, adequately distributed geographically, on the **radiation budget components at the Earth's surface** for climate research;

Recommends that: (1) WMO and ICSU urge all their members to submit data sets from as many stations as possible to the World Radiation Data Center in Leningrad, according to the recommended procedures which are specified in World Climate Programme Publication No. 48; (2) WMO and ICSU members establish calibration and inspection routines for experimentally operated stations in addition to the national networks; and (3) special climatic data sets be prepared for sensitive and important areas of the Earth for which the data density is still sparse (for example semi-arid areas, the Arctic sea ice and the Antarctic continent, and the world oceans).

17. Recognizing the **difficulties of scientists in obtaining adequate climate data** for research on meteorology, climatology, and climate impacts studies;

Noting that one of the primary objectives of the World Climate Data Programme is to make climate data more available in convenient formats;

Urges the WMO to arrange for compilations of climate data to be made available from international or national data centers to individual scientists for their research in convenient and multi-purpose formats at concessional rates, especially to scientists in developing countries.

18. Considering the importance of highly accurate **absolute gravity measurements** for geophysical and geodetic research and applications;

Recognizing that future comparisons of different absolute gravity apparatus are necessary to study sources of systematic error;

Requests the support of the Bureau Internationale des Poids et Mesures (BIPM) (International Bureau of Weights and Measures) in hosting an international campaign to compare absolute apparatus; and

Requests all countries having transportable apparatus to take part in the campaign and the subsequent data reduction and analysis.

19. The Council of the IUGG records with great pleasure its appreciation of the efficient yet relaxed organization of both the scientific and supporting programs, and on behalf of all participants offers its heartfelt thanks to the National Committee of the Bundesrepublik Deutschland, the Local Organizing Committee, and all others concerned for making **the XVIIIth, the largest-ever General Assembly**, such a pleasant and scientifically satisfying experience.

Membership Applications Received

Applications for membership have been received from the following individuals. The letter after the name denotes the proposed primary section affiliation.

Ross S. Bartell (G), Terence J. Bottrill (V), Joseph S. Dalin (H), C. U. Ezeigbo (G), José M. Febrer (GP), Peter Giese (S), Hans-Peter Harjes (S), Joesil Kahar (G), Eli Joel Katz (O), Robert I. Odom (S), Erik Romijn (H), Miguel A. Uliana (T), Ronald Veitch (GP), Gerold Wefer (O), Helmut Wilhelm (S).

Student Status

John Del Ferro (H), Ronald Filadelfo (O), Nikolaos Fries (T), Scott G. Schapper (S).

GAP

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Aeronomy

0340 Tides, Waves and Winds
THE GEOMAGNETIC QUIET NIGHTTIME THERMOSPHERIC WIND PATTERN OVER FRITZ PEAK OBSERVATORY DURING SOLAR CYCLE MINIMUM AND MAXIMUM
C. Hernandez (Fritz Peak Observatory, Aeronomy Lab, NOAA, Boulder, Colorado 80303) and R.G. Roble

Nighttime thermospheric winds and temperatures at F-region heights have been measured over Fritz Peak Observatory, Colorado (39.9°N, 105.5°W), with a high-resolution Fabry-Perot spectrometer from about November 1972 to the present. The winds and temperatures are obtained from the Doppler shifts and line profiles of the (OI) 15,867 K (630-nm) line emission. The data obtained during geomagnetic quiet conditions (Ap<20) have been separated into two groups representing solar cycle minimum conditions (1972-1977) and solar cycle maximum conditions (1978-1979). The monthly variation of the nighttime zonal and meridional winds are presented for both groups. The results show that during solar cycle minimum the zonal winds are predominantly eastward during the winter months at speeds of 50-75 m s^{-1} and westward during the summer months at speeds of 50-100 m s^{-1}. The meridional winds measured to the north and south of Fritz Peak Observatory are equatorward throughout most of the night at nearly the same speed. The equatorward winds in the summer peak near midnight at about 100-150 m s^{-1}. The equatorward winds in the winter also peak near midnight but with smaller speeds, 50-75 m s^{-1}.

During solar cycle maximum the zonal winds are again predominantly eastward during the winter months, reaching peak speeds of 60-75 m s^{-1} in the early evening hours and decreasing afterwards. In the summer the winds are eastward during the early evening hours, shifting to westward near midnight and increasing to a maximum speed of 75-100 m s^{-1} in the early morning hours. The meridional winds are poleward at ~20 m s^{-1} in the early evening hours, shifting to equatorward near 21 LT and then increasing in magnitude with maximum speeds near or after midnight. There is a considerable difference in the speed of the winds measured to the north and south of Fritz Peak Observatory. During the summer the equatorward winds measured to the north are 150-175 m s^{-1}, whereas the equatorward winds measured to the south are 75-75 m s^{-1}. During the winter the speeds are smaller, 50-75 m s^{-1} and 25-30 m s^{-1} to the north and south of the station, respectively.

Calculations made with the NCAR thermospheric general circulation model (TGCM) for different seasons are in reasonable agreement with the observations during both solar minimum and solar maximum. During solar cycle maximum the observed and calculated meridional wind differences to the north and south of Fritz Peak Observatory are attributed to enhanced auroral heating and ion drag associated with magnetospheric convection north of the observatory. The equatorward driven winds slow south
J. Geophys. Res., Blue, Paper 3A1446

Electromagnetics

0310 Electromagnetic Theory
PROPAGATION OF A GEOMETRICAL OPTICS FIELD IN AN ISOTROPIC INHOMOGENEOUS MEDIUM
A. Bremer, S. W. Lee (Department of Electrical Engineering, University of Illinois, Urbana, Illinois 61801)

The cross-section of an infinitesimally small ray tube (ray pencil) expands or contracts as rays propagate. The square root of the cross-section ratio between two points on a ray is defined as the divergence factor DF. In a homogeneous medium, rays are straight lines. Consequently, $(DF)^2$ is simply equal to the ratio of Gaussian curvatures of the wavefronts. In an inhomogeneous medium, rays are curved, and DF becomes more complex. In this paper, we derive several integral expressions for calculating DF and the related formulas that govern the field and energy variations along a ray. (Geometrical optics, inhomogeneous medium, ray optics, wave propagation).
Rad. Sci., Paper 3S1480

Exploration Geophysics

0925 Magnetic and electrical methods
HOMOMORPHIC DECONVOLUTION: APPLICATION TO GRAVITATIONAL AND MAGNETIC FIELD WAVEFORMS
Pandelis K. P. Papazis (Amoco Production Company, 1670 Broadway, Denver, CO 80202) Oliver G. Jensen

The gravitational and magnetic field waveforms which represent potential fields of geologic structures can be expressed as the sum of overlapping, delayed replicas of a certain basic waveform. Such field waveforms, therefore, can be thought of as the outcome of a convolutional process. One way of separating signals which have been combined through convolution or multiplication is by using a set of systems called homomorphic systems. A particular feature of the process called homomorphic deconvolution is that no previous assumption of the character or nature of the basic waveform need be made. It is this feature of homomorphic deconvolution which makes it attractive for applications to gravitational and magnetic field waveforms.
GEOPHYSICS, VOL. 48, NO. 10

0930 Seismic methods
APPROXIMATE COMPUTATION OF THE ACOUSTIC IMPEDANCE FROM SEISMIC DATA
B. A. Bertteussen (Saga Petroleum, P.O. Box 9, Hovik, Norway) B. Ursin

The approximate computation of the acoustic impedance from seismic data is usually based on the recursive formula

$$\lambda_{k+1} = \lambda_k \frac{1+c_k}{1-c_k}$$

where λ_k is the acoustic impedance in layer number k and c_k is the pressure reflection coefficient for the interface between layer k and $k+1$. The above formula is derived from a discrete layered earth model. When we consider a continuous earth model and discretize the results, we obtain the recursive formula

$$\lambda_{k+1} = \lambda_k \exp(2c_k).$$

The two expressions give very similar numerical results. For $c_k \le 0.4$, the relative difference is less than 5 percent and this cannot be visually recognised on an acoustic impedance section.

The expression for the continuous model is more suitable for understanding the result of the approximate computation of the acoustic impedance function from band-limited seismic data. The calculated impedance minus the impedance in the top layer is approximately equal to the reflectivity function convolved with the integrated seismic pulse multiplied with twice the impedance in the top layer. For impedance values less than 0.2 in absolute value this is also equal to the acoustic impedance function (minus the acoustic impedance in the top layer) convolved with the seismic pulse.

The computation of the acoustic impedance from band-limited seismic data corresponds to an exponential transformation of the integrated seismic trace. On a band-limited acoustic impedance section with well-separated reflectors and low noise level the direction of change in the acoustic impedance can be correctly identified.

The effect of additive noise in the seismic data is governed by a nonlinear transformation. Our data examples show that the computation of acoustic impedance becomes unstable when noise is added.

In order to avoid the nonlinear transformation of the seismic data, it has been suggested to integrate the seismic data. This results in an estimate of the logarithm of the acoustic impedance for band-limited estimate of the logarithm of the acoustic impedance plus the integrated noise. A disadvantage of this method is that the variance of the integrated noise increases linearly with time.
GEOPHYSICS, VOL. 48, NO. 10

0930 Seismic methods
FAST SEISMIC INVERSION
See 0910 Computer applications
W. Keith McClary (230 10A St. N.W., Calgary, Alta., Canada T2N 1W6)

The equal traveltime layer model of a horizontally layered medium with waves at normal incidence is used to solve the inverse problem (determination of the reflection coefficients and fundamental polynomials from the surface response) by an efficient algorithm using $O(N(\log_2 N)^2)$ computations for N layers. The idea is to reduce the N-layer problem to two similar problems of $N/2$ layers each plus additional computations of type B and C. Type B computes the data for the second problem from the result of the first and type C combines the results. For $N = 2^k$ the reduction is carried out k times leading to N trivial one-layer problems plus more computations of type B and C, which are polynomial multiplications or discrete convolutions. The improvement over the $O(N^2)$ computations required by recursive methods comes from using the fast Fourier transform to perform the convolutions.
GEOPHYSICS, VOL. 48, NO. 10

0930 Seismic methods
AUTOREGRESSIVE RECOVERY OF THE ACOUSTIC IMPEDANCE
Colin Walker (Department of Geophysics and Astronomy, University of British Columbia, Vancouver, B.C., Canada V6T 1W5) Tad J. Ulrych

This paper presents a method of recovering the acoustic impedance from reflection seismograms using autoregressive (AR) modeling, an approach originally applied to deconvolution by Lines and Clayton (1977). The algorithm which we describe is novel both in the manner in which the missing low- and high-frequency information is predicted, and in the fact that the prediction may be constrained if acoustic impedance information is available. The prediction of the low frequencies treats the missing data as a gap which extends from the low-frequency cut-off in the negative frequency band to the corresponding frequency in the positive frequency band. The conjugate symmetry which governs the behavior of the spectrum in the band is taken into account in the prediction. The missing high frequencies are predicted using a modified minimum entropy norm in the frequency domain.

Both synthetic and field examples are presented and illustrate the robustness of the new AR algorithm under a variety of conditions. The field example also compares the results obtained using the AR algorithm with the linear programming method of Oldenburg et al (1983). The agreement in results is particularly gratifying in view of the differences in the two inversion schemes.
GEOPHYSICS, VOL. 48, NO. 10

Geodesy and Gravity

1920 Geometric observations and methods
TEMPERATURE STRATIFICATION AND REFRACTION ERRORS IN GEODETIC LEVELING
R. H. Shaw (Department of Land, Air and Water Resources, University of California, Davis, California, 95616) and P. J. Smielens, Jr.

Refraction errors in geodetic leveling due to temperature stratification of the lower atmosphere are presented within the framework of Monin-Obukhov similarity theory. Universal expressions for the non-dimensional mean temperature gradient, accounting for both buoyant convection and mechanically-inducing mixing, were incorporated into the integration of ray path height with imposed refractive curvature to obtain estimates of the net error in elevation difference on sloping terrain. Exact solutions were found for the refraction error, but approximate versions had the advantage that a normalized refraction error was independent of shot length and terrain slope. Calculations demonstrated that refraction errors increase monotonically with increasing surface heat flux but maximum errors are found at a finite value of the wind speed such that the ratio of the telescope height to the Obukhov length is independent of heat flux. A free convection approximation provided a close match to the maximum refraction error found from the more general solution for the same surface heat flux, indicating that a free convection approximation yields an upper bound to the refraction error. Calculations of refraction error based on environmental measurements taken during a 1981 survey between Saugus and Palmdale, California, showed that a free convection approximation overestimated the refraction error by a factor ranging from 1.09 to 1.53 depending on the magnitude of the surface roughness length. (Atmospheric refraction, leveling errors).
J. Geophys. Res., Red, Paper 3B1412

1980 Tides
NUMERICAL SIMULATIONS OF THE ROSS SEA TIDES
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Tidal currents below the floating Ross Ice shelf are reconstructed using a numerical tidal model. They are predominantly diurnal, achieve maximum strength in regions near where the ice shelf runs aground, and are significantly enhanced by topographic Rossby-wave propagation along the ice front. A comparison with observations of the vertical motion of the ice-shelf surface indicates that the model reproduces the diurnal tidal characteristics within 20%. Similar agreement for the relatively weak semidiurnal tides was not obtained, and this calls attention to possible errors of the open-boundary forcing obtained from global-ocean tidal simulations and to possible errors in mapping zones of ice-shelf grounding. Air-sea contact below the ice shelf is eliminated by the thick ice cover; thus the dominant sub-ice-shelf circulation may be tidally induced. A preliminary assessment of sub-ice-shelf conditions based on the numerical tidal simulations suggests that: (1) strong barotropic circulation is driven along the ice front, and (2) tidal fronts may form in the sub-ice-shelf cavity where the water column is thin and where the buoyancy input is weak. (Tides, glaciology).
J. Geophys. Res., Green, Paper 3C1414

Geomagnetism and Paleomagnetism

2530 Spatial variations full harmonics and anomalies
VARYING GEOMAGNETIC ANOMALIES AND SECULAR VARIATION
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The time variations of the geomagnetic field at 10 European observatories were examined in detail. Fourier analyses were made for three field components at each of the observatories. Curves for each component were synthesized for three passbands: A low passband for periods greater than 30 years, a mid passband for periods equal to or less than 30 years but greater than 13 years. The low passband results show only very smooth variations from which the linear prediction of secular variation, as is now in use, might give a good average result for 10-15 years if there were no other changes. The high passband results show the solar cycle effect that has been adequately treated before. The mid passband has an amplitude of tens of nT which changes differently at each observatory in such a way as to infer core sources. These time-varying anomalies are important to the understanding of secular variation. (Secular variation, anomalies, time variations)
J. Geophys. Res., Red, Paper 3B1061

2560 Time variations, paleomagnetism
GEOMAGNETIC PALEOINTENSITIES FROM EXCURSION SEQUENCES IN LAVAS ON OAHU, HAWAII
Robert S. Coe (Earth Sciences Board, University of California Santa Cruz, California), Sherman Grommé and Edward A. Mankinen

Paleomagnetic data demonstrating three late Tertiary excursions in the direction of the geomagnetic field recorded in sequences of basaltic lavas on the island of Oahu, Hawaii were published by R.R. Doell and G.B. Dalrymple in 1973. We have determined geomagnetic paleointensities by the Thelliers' method for fourteen lavas from the three sites. Considerable difficulty was encountered during these experiments, caused by the presence of titanomaghemite in many lavas and contamination of NRM by lightning in many others. Moreover, we often observed the production of spurious high-temperature chemical remanent magnetization during the Thellier experiments. An analysis of this particularly troublesome problem is presented. Two of the sites showed low paleointensities associated with angular departures of the paleomagnetic field direction from that of a geocentric axial dipole, which suggests that these excursions represent aborted reversals or fragments of reversals. At the third site, however, the paleointensity did not become low as the field diverged. This excursion may reflect the variation of a large nondipole source near Hawaii.
J. Geophys. Res., Red, Paper 3B1508

Meteorology

3715 Chemical composition and chemical interactions
MEASUREMENT AND MODELLING OF THE CONCENTRATIONS OF TERPENES IN CONIFEROUS FOREST AIR
Oystein Hov (Norwegian Institute for Air Research, P. O. Box 130, N-2001 Lillestrom, Norway), J. Schjoldager and B. M. Wathne

In a coniferous forest area northeast of Oslo, Norway, air samples were collected by absorption on activated carbon and analysed by gas chromatography with a high resolution glass capillary column and flame ionization detection. During June and August 1980, seven terpenes were identified with a total concentration range of 8.8-70.7 ppbC. α-pinene, terpinene and p-cymene occurred in the highest concentrations.

A one-dimensional vertical grid model of the atmospheric boundary layer with a detailed mechanism for inorganic and organic gas phase chemical turnover was applied to assess the vertical variability of the terpene concentrations as a function of the ozone concentration, the source strength of the terpenes, the time of the day, the upwind air composition, etc. The calculations showed that very little of the terpene emissions remained airborne after 4-8 h, in contrast to the anthropogenic hydrocarbons. It was found that the anthropogenic fraction of the hydrocarbons may dominate in concentration even though the natural part of the source is the larger one. Emission of 2000 $\mu g (m^2 h)^{-1}$ of terpenes was calculated to give ground level concentrations of total terpenes of up to about 25 ppbC, comparable to or less than the measured concentrations. Terpene emission at this rate was shown to suppress the hydroxyl concentration compared to a model case with zero terpene emissions, while the impact on ozone during daytime was negligible.
J. Geophys. Res., Green, Paper 3C1454

3750 H_2O in the atmosphere
MONTHLY DISTRIBUTIONS OF PRECIPITABLE WATER FROM THE NIMBUS-7 SMMR DATA
H.D. Chang (Systems and Applied Sciences Corp., 5809 Annapolis Road, Hyattsville, Maryland 20784), P.H. Hwang, T.T. Wilheit, A.T.C. Chang, D.H. Staelin, and P.W. Rosenkranz

The first year of data from the Nimbus-7 Scanning Multichannel Microwave Radiometer (SMMR), covering the period December 1978 through November 1979, was used to study the monthly mean distributions of precipitable water over the global oceans. The water vapor algorithm is based on a multiple regression technique, utilizing three of the higher frequency channels on SMMR. The results obtained are in good agreement with other independent studies. They reveal features associated with the general circulation of the atmosphere and the ocean currents. Samples of monthly and annual distributions of precipitable water over oceans are presented, and their characteristics are discussed. (Nimbus-7, Remote Sensing, SMMR, Water Vapor)
J. Geophys. Res., Green, Paper 3C1455

3755 Electrical Phenomena (Thunderstorm Electrification)
RADAR TESTS OF THE PRECIPITATION HYPOTHESIS FOR THUNDERSTORM ELECTRIFICATION
E. R. Williams (Department of Earth and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139), R. M. Lhermitte (Rosenstiel School of Marine and Atmospheric Science, University of Miami, Miami, Florida 33149)

The contribution of falling precipitation to thunderstorm electrification is examined from an energy standpoint by means of radar measurements of precipitation. The gravitational power associated with falling precipitation is compared with estimates of the thunderstorm electrical output as a test of a causal relationship between these two quantities. The relative importance of the gravitational and electrical forces acting on precipitation particles is investigated by monitoring the stability of particle vertical motions to lightning-associated changes in electric field. The general absence of abrupt particle velocity changes is difficult to reconcile with the gravitational power determinations in electrically active storms unless the electrical energy contribution from convective motions is substantial. (Precipitation mechanisms, electrical energy, radar measurements).
J. Geophys. Res., Green, Paper 3C1440

Planetology

6540 Planetology (Interior of Moon)
ANCIENT CRUSTAL COMPONENTS IN THE FRA MAURO BRECCIAS
J. W. Shervais, and L. A. Taylor (Univ. Tenn., Knoxville, TN, 37996) and J. C. Laul (Battelle NW, Richland, WA 99352).

Texturally pristine clasts preserve primary petrographic relationships and mineral compositions, yielding insights into igneous processes of the early lunar crust that cannot be gained from highly shocked and brecciated 'chemically pristine' samples. The use of texture as a prime criterion allows for expansion of the data base derived solely from chemical criteria, and provides complementary data. Texturally pristine clasts from the Apollo 14 site studied here include anorthosite, troctolites, gabbronorites, and basalts. Alkali anorthosites are plagioclase orthocumulates and may form by flotation in Mg-suite plutons. Ferroan anorthosite was cataclastically deformed and metamorphosed to granulite facies. Troctolites include both Ol + Plg and Ol + En + Plg cumulates. Major and trace element analyses of two troctolites reveal 'eastern' geochemical affinities that contrast other 'western' troctolites. Gabbronorites are Plg + Plg + Sp cumulates whose parent magmas may range from high-Al to intermediate-Ti mare basalt. At least three varieties of mare basalt are found at Apollo 14: high-Al, low-Ti; low-Al, intermediate-Ti; and low-Al, Ti VHK basalt. VHK (Very High Potassium) basalt is a new variety indigenous to Apollo 14.
J. Geophys. Res., Red, Paper 3B5034

6560 Meteoritics
HIGH RESOLUTION MULTIPATH MEASUREMENTS OF THE METEOR SCATTER CHANNEL
J. A. Weitzen (SIGNATRON, Inc., 12 Hartwell Avenue, Lexington, MA 02173), M. D. Grossi, W. P. Birkemeier

An experimental method for determining the multipath spread of the meteor scatter communications channel is discussed. The technique measures the spreading of equalization pulses contained in commercial television signals received via meteor scatter. Resolution of spread to within 0.5 microsecond is possible with this technique.
Rad. Sci., Paper 3S1388